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BREEDING HABITS OF THE VIVIPAROUS FISHES
GAMBUSIA HOLBROOKII AND *HETERANDRIA*
FORMOSA.

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The two species under observation belong to a well-defined group of small fishes the members of which are variously known as "Top Minnows," "Mud Minnows," "Pike Minnows," "Killifishes," etc. The generic name *Gambusia* was suggested to the late Professor Poey by the common name in use in Cuba, *Gambusino*, meaning small and of no importance. The members of this genus are larger than those of *Heterandria* and have a more northerly range; the females, however, though usually twice as large as the males, rarely reach a length of two and one half inches. Until the discovery by Dr. Smith that the little fish named by him *Mistichthys* reached the adult stage at less than an inch in length *Heterandria* was about the smallest known vertebrate. According to Garman the range of *Gambusia holbrookii* is from Virginia to Alabama and is represented in the tributaries of the Mississippi and westward to Mexico by its close ally *G. patruelis*. *Heterandria formosa* is abundant in swamps and ditches coastwise from the Carolinas to Florida. It rarely exceeds an inch in length.

Gambusia was introduced into New Jersey in 1905 and from observations made by me of both it and *Heterandria* since 1906 the habits of the two are, so far as discernible, exactly similar. They are the most northerly representatives of the viviparous genera of the family Poeciliidæ. They are easily kept in small glass jars where they breed readily, eating anything that a goldfish will eat, either vegetable or animal, and as insect destroyers have no superiors.

The only recorded observation of the breeding habits of *Gambusia* is to be found in the proceedings of the U. S. National Museum for 1885, credited by the late Prof. John A. Ryder to A. A. Duly an employee of the Museum. This account appears also as a footnote to Bulletin No. 47, U. S. Nat. Mus., Fishes of North America.

Having observed the act of coition and of the extrusion of the young of both of these species a great many times every year, beginning with 1906, I am satisfied that Mr. Duly's account of it is, in many respects at least, incorrect. First, he says, "In coitus the male's head is turned in the direction of the tail of the female, the prolonged anal fin seeming to be thrust into the external opening of the ovarian duct or genital pore of the female, which lies just in advance of the anal fin." I have never witnessed anything like that, nor is it an analogical method. On the contrary the male follows incessantly and warily after the female, on the left side and to the rear, the female frequently turning and making savage dives at him causing him to turn and flee, but to return immediately and follow, watching for a moment when her attention will be distracted when he will make a sudden dash, sometimes succeeding in inserting the intromittent organ into the genital pore, but oftener, apparently, missing because of a quick turn of the female from which he flees in apparent terror. The contact is so sudden and brief that it required many observations to verify it. In these movements the male organ is thrust forward and to the right toward the female. In small jars the males are frequently killed, especially when the female is full sized, or if there are two or three females to one male. It has been noted that when catching them there appears to be a great preponderance of females, but that might be due to the fact that as the males are much smaller than the females they could more easily escape through the meshes of a net.

In the aquarium the males are continually engaged in a pursuit of the females while the females are apparently adverse to sexual dalliance and at all times unwilling participators and quick to resent the advances of the males. I have never witnessed anything to indicate a reciprocity of desire in coitus it being always a chance touch and go on the part of the males. There is never more than the one male following a female. If others approach, the male turns and drives them off.

Of course, normal action in fishes confined in aquaria is dependent on a satisfactory environment—warmth, proper food, etc. If conditions are unfavorable and they are not comfortable there will be no sexual demonstration.

Prof. Ryder says further: “The young, when born, are stated by Mr. Duly to be about $\frac{3}{8}$ of an inch in length and to be expelled in a single mass, consisting of 8 to 11 young fishes at a single effort. This mass as soon as it escapes is seen to be composed of the infant *Gambusia*, which at once separate and move away. No membrane seemed to be expelled together with the mass of young, so that it is probable that in this species, as in *Anableps* and the *Embiotocidæ* the foetuses rupture the follicles in which they developed a short time before birth.”

One has only to open a gravid female to see that Mr. Duly's account of the birth of *Gambusia* would be a physical impossibility. The ova of a full sized *Gambusia* are, when fully developed, about an eighth of an inch in diameter, transparent and non-adhesive. Each one is held, apparently, by a thread of membrane to a central nucleus the character of which could only be determined by microscopic examination. The young fish can be seen fully formed, their eyes moving as they turn around in the egg. They are expelled one at a time and the ejection of each fish is so rapid that they appear as though shot out with some force. This, however, might be due to the bursting of the follicle and the uncoiling of the fish as it is released from restraint. When they first appear they are still in a somewhat curved form but they quickly straighten out and swim into hiding. The follicles are undoubtedly ruptured at the moment of extrusion, whether inside or out, I never succeeded in observing, but it appears the more probable that it is inside. The young fish are already pigmented and altogether unlike the generality of embryo fishes. Oviparous species, when hatched, having an umbilical sac and being for some time unable to feed and quite helpless. They are also transparent and very delicate, while the young of the viviparous fishes are apparently, except in size and the development of the male sexual organ, as fully developed as the adult. I would say that $\frac{7}{16}$ to $\frac{1}{2}$ inch is nearer the size of the fish when born than $\frac{3}{8}$ inch, although the size, no doubt, varies with the size of the female. The intervals between the extrusions vary from several

minutes to as many hours. The number given off at one time varies also. After the extrusion of such young as have been developed, there is a period of rest of several days during which another lot is developed, a limited number of eggs only being fertilized at each sexual contact. I can not do better than to copy a series of notes taken from my observations.

1906. July 14 to 16. *Heterandria* female extruded 16 young. Some appeared on 14th, some on 15th, and some on 16th. Last previous delivery from same female was seven young. Three prior deliveries at intervals not noted, but not greater than the last mentioned one, resulted in the delivery of five, seven, and seven, respectively. It is impossible to say whether those numbers represent accurately the respective deliveries, as some were born at night and at other times when they were not under observation, and some may have been eaten.

July 21st (five days later). Found 9 young and on 23d found 2 more. Saw the female eat one of these. This may only occur when other animal food is wholly absent, or in the case of such young as are imperfect—deficient in vitality or deformed in some way. On the other hand there seems to be a universal tendency on the part of the females of all nest building fishes to devour their eggs and young. This may also be characteristic of females of viviparous species. The writer has recorded the action of male sticklebacks in frightening their young by darting at them as though to devour them, causing them to rush to cover among the plants. This is undoubtedly a continuance of the protective habit from the eggs to the young until they are capable of self protection.

August 1st (8 days interval), found 4 young. August 2d, found 12; August 4th and 5th, 2 more, making 18 in all.

August 10th–11th (5 days interval), found 4 more.

August 18th (7 days interval), found 10.

These fish grow and develop very rapidly if properly fed.

I had paired two that had been hatched early in May. On July 27th I found one young in the jar but at first supposed it must have been in the jar hiding among the plants when the breeders were introduced, as I could not conceive of two generations of fish in one season, it being so contrary to the habits of fishes in general. But on August 18th I found 6 young about which there could be no doubt.

August 26-27, found 5 more.

September 3d to 10th found several more. Also found several young with a pair hatched early in July.

It is thus positively demonstrated, not only that there can be two or more generations of these species born in a summer, but also a second generation in less than three months, so that although the fecundity is not so great as with oviparous species there is more rapid reproduction as well as protection both through the egg stage and by reason of the greater development and activity of the young when first hatched, the danger period with the others. This will account for the great numbers of these species where they abound, notwithstanding they are the prey of all the larger species.

I have repeated these observations several times with both species with the same general results—any difference being in the varying numbers produced, which, however, were a close approximation.

Notwithstanding that these two species live together apparently in perfect harmony there is sexually an apparently rigid racial antipathy. I have succeeded a number of times in hybridizing a male *Gambusia* with a female *Heterandria*, but not the reverse, probably because of the very small size of the males of the latter species. The offspring of these crosses had the appearance of *Gambusia*, none of the conspicuous markings of *Heterandria* appearing on any of them. They were fertile and reproduced, but the young also had the appearance of *Gambusia*. This fact would have caused me to suspect a mistake somewhere in the course of the experiment if I had heard or read of it, but I know that there was no possibility of error because they were isolated in small jars with no change or interference. If it were not for such an antipathy, which appears to be confined to the females, the species would soon be intermixed.

The attitude of the female *Heterandria* toward the male *Gambusia* was even more hostile and savage than that of females of the same species. She would not only repulse him savagely but at times would follow him biting him viciously until he succeeded in hiding from her. Notwithstanding these vicious rebuffs he would soon be back, following persistently at the left and rear, rushing and retreating all through the hours of daylight at least.

The female *Heterandria* is at least double the bulk of a male *Gambusia*, though not of much greater length, and much more than a match for him. In the attacks of the females of either species they seem to endeavor to bite the long slender organ of the male, which is no doubt the most vulnerable point.

This pair were together for two summers and the production of young throughout was approximately the same as that of the pair of *Heterandria* previously mentioned.

Notwithstanding the viciousness displayed by the females with apparently no sign of yielding, there may be a cessation of hostilities during the darkness of night as they appear much more quiet in a dim light. There may be times also when there is a yielding from sexual impulse, but I have never been able to observe it. This is probable and would be analogous to the conduct of higher animals.

The male generative organ, as may be seen by the accompanying figures, is extremely long in proportion, being almost a third as long as the fish. It can be thrown completely in a circle close against the body of the fish as though working on a pivot.